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January 22, 1962

Dr. T. L. K. Smull, Assistant Chief
Office of Research Grants and Contracts
National Aeronautics and Space Administration
1520 H Street, N. W.
Washington 25, D. C.

Subject: Quarterly Report on "Reflection Spectra as a Basis for Studying Extraterrestrial Life" - NsG-101-61 (Series 2, Issue 16)

Dear Mr. Smull:

Only a limited amount of data has been obtained on the infrared reflection spectra of biological species. This has been due to a variety of instrumental problems, due either to the extreme demands we are placing on the Beckman IR-7 or to breakdowns in the instrument itself. However, the data obtained have confirmed earlier conclusions that greater caution must be shown in interpreting the reflection spectra of Mars than has been exhibited by previous workers in the literature, who have assumed the reflection spectrum to be identical with the absorption spectrum.

The reflection spectrum of an Agapanthus leaf shows two maxima at 2860 and 2930 cm.$^{-1}$ and a minimum at 1745 cm.$^{-1}$, the former feature being due to CH stretching and the latter to a C=O stretching vibrations. All of these features correspond exactly to minima in the absorption spectrum. The CH bands are strongly polarized.

A specimen of a foliose lichen gave intense maxima in reflection at 2790 and 2840 cm.$^{-1}$ which were depolarized.

The photosynthetic bacteria Rhodospirillum Rubrum gave maxima and minima in the 2000-1000 cm.$^{-1}$ region, with shifts of 30-60 cm.$^{-1}$ from the principal features of the absorption spectrum. The CH stretching band gave a broad minimum with no sign of a maximum. Similar spectral observations were made for the green alga Chlorella.

These data show clearly that the reflection spectrum is certainly not identical with the absorption spectrum for biological specimens. The reflected radiation can have simultaneously maxima, minima, and band shifts, and is related in a complex manner to the absorption characteristics.

A specimen of the alga Cladophora showed minima at 2865 and 2930 cm.$^{-1}$ in both transmission and reflection spectra. The band which Sinton reports at 2743 cm.$^{-1}$, and which he assigned to carbohydrates, is not observed.

It is almost certain that the 2710 cm.$^{-1}$ band Sinton observes in his Mars spectrum is not due to carbohydrates as he proposes. It is far too intense relative to the higher wavenumber bands for this explanation to hold. Colthup's (Colthup, N. B. Science 134, 529 (1961)) suggestion that this band may be due to gaseous acetaldehyde is acceptable and is not invalidated by the relative band intensities.

Work is continuing on measuring the infrared reflection spectra, together with band polarizations, of materials of potential interest to the surface of Mars.

The construction of the infrared Michelson interferometer for planetary observations, using the 120 inch Lick telescope, has progressed slowly due to long delivery times of the components and to delays in setting up our machine shop. Most of the obstructions are out of the way so that the work now should progress at a considerably faster rate.

Very truly yours,

Samuel Silver,
Director, Space Sciences Laboratory

SS:mh

cc: Prof. M. Calvin
Prof. H. Weaver
Dr. C. Sagan
Dr. D. Rea
Mr. T. Belsky